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# Optimal Tariffs with Smuggling:

## A Spatial Analysis of Nigerian Rice Policy Options

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## ABSTRACT

Utilizing a spatial multi-market model for rice in Nigeria that explicitly takes into account the potential for smuggling, in this paper we analyze the welfare implications of alternative rice tariff rates given the government's goals of spurring domestic production and reducing imports. Because smuggling occurs through the diversion of imports from Lagos, the official port of entry in the south, to the north, our modeling framework also captures the spatial effects of higher tariffs on changes in rural and urban prices, production and consumption, the flow of trade in rice, and welfare across different parts of the country. Results show that tariff rates that exceed about 40 percent introduce some smuggling of rice through the north when smuggling becomes more profitable than importing through official channels in the south. It is also at this tipping point that government tariff revenues are maximized. At higher tariff rates with smuggling, the south experiences greater welfare losses, especially in urban areas.

**Keywords:** optimal tariff, smuggling, spatial market equilibrium model, rice, Nigeria

## I. INTRODUCTION

As in many West African countries, rice consumption and imports in Nigeria have grown very rapidly in the last few decades. Rice is now a leading food staple in Nigeria, accounting for 11.2 percent of calories consumed and 6.6 percent of household food expenditures (FAO 2014; Gyimah-Brempong & Kuku 2014). Although production has increased rapidly in recent years, longer term growth rates are low and rice imports have surged from an average of 590 thousand tons per year in the 1990s to 2.42 million tons in the period 2010 to 2012 (Table 1).

**Table 1—Nigeria average annual rice imports, production, and domestic availability, 1960-2012**

Period	Rice Imports (thousand tons)	Rice Production (thousand tons)	Rice Domestic Availability (thousand tons)	Share of Imports in Availability (percent)
1960-69	1	222	201	0.5
1970-79	199	357	520	38.3
1980-89	529	866	1,308	40.4
1990-99	590	1,818	2,226	26.5
2000-04	1,679	1,851	3,346	50.2
2005-09	1,790	2,131	3,653	49.0
2010-12	2,417	2,725	4,869	49.6

Source: USDA data.

Notes: All quantities are milled rice.

This large increase in imports has not gone unnoticed by the Nigerian government, which considers it a major policy concern. In particular, rice features prominently in the government's agricultural development strategy, the Agricultural Transformation Agenda (ATA), launched in 2012. Aside from increasing public investments in the sector to raise productivity, volumes, and quality of output, the ATA strategy included the introduction of higher rice import tariffs in order to slow the growth in rice imports. Thus, government increased the import tariff on rice from 50 percent to 110 percent in January 2013. However, customs data, price movements, and anecdotal evidence from field observations by the authors suggest that the increase in the rice tariff led to the bulk of rice imports being diverted from official channels to informal ones, either through customs evasion at the main port in Lagos or through smuggling from neighboring countries, especially Benin and Niger.

In this paper, utilizing a spatial multi-market model for rice in Nigeria that explicitly takes into account the potential for smuggling, we analyze the welfare implications of alternative rice tariff rates given the Nigerian government's goals of spurring domestic production and reducing imports of rice. Our modeling framework also captures the effects of alternative tariff levels on rural and urban prices, production, consumption, economic surplus, and government revenues. Section 2 of this paper presents a brief overview of Nigeria's rice economy, with a focus on trade policy and imports. Section 3 describes the simulation model, data, and parameter values. Simulation results of the impacts of a range of import tariffs under alternative assumptions of the extent of smuggling are given in Section 4. Section 5 reviews results from sensitivity analyses of key model assumptions and parameters. We discuss policy implications and conclusions in section 6.

## **2. NIGERIA'S RICE ECONOMY AND RECENT TRADE POLICY**

Rice production in Nigeria has increased substantially since the 1960s, but rice still accounts for a relatively small share of area cultivated, as wide variations in rainfall, soil characteristics and water availability, as well as farmers' risk reduction strategies, all contribute to the widespread cultivation of cassava, yams, maize, sorghum and millet across Nigeria (Takeshima and Bakare, 2015). Related to this diversified production pattern, the composition of staple food production also varies across Nigeria, with sorghum and millet consumed widely in northern Nigeria and maize and root crops dominating consumption patterns in the south and middle zones. Overall, five crops each account for about 10 percent of national calorie consumption – rice (11.2 percent), yams (10.1 percent), cassava (10.1 percent), maize (9.9 percent) and sorghum (9.3 percent). Wheat, with very little domestic production, accounts for 6.6 percent of total calorie consumption (FAO, 2014).

Rice cultivation is concentrated mainly in Nigeria's middle belt in areas where seasonal flooding or water from streams and rivers provide sufficient water. Low yields, high production costs, and lack of sufficient modern milling technologies contribute to the comparative disadvantage of domestic rice production relative to imports. Recent work by Johnson (forthcoming) estimated overall production costs along the rice value chain as twice those found in Thailand, for example. Rice milling is dominated by small scale millers who produce varying qualities of standard milled rice, often with significant impurities (Johnson forthcoming). As a result, consumers typically prefer premium rice varieties that either are imported or are produced locally by a few large scale millers. Nevertheless, Government efforts to boost rice production have met with considerable success in recent years, as evidenced by a 4.2 percent average growth rate from 2005 to 2012 in Figure 1. However, growth in demand for rice has outpaced production increases.<sup>1</sup>

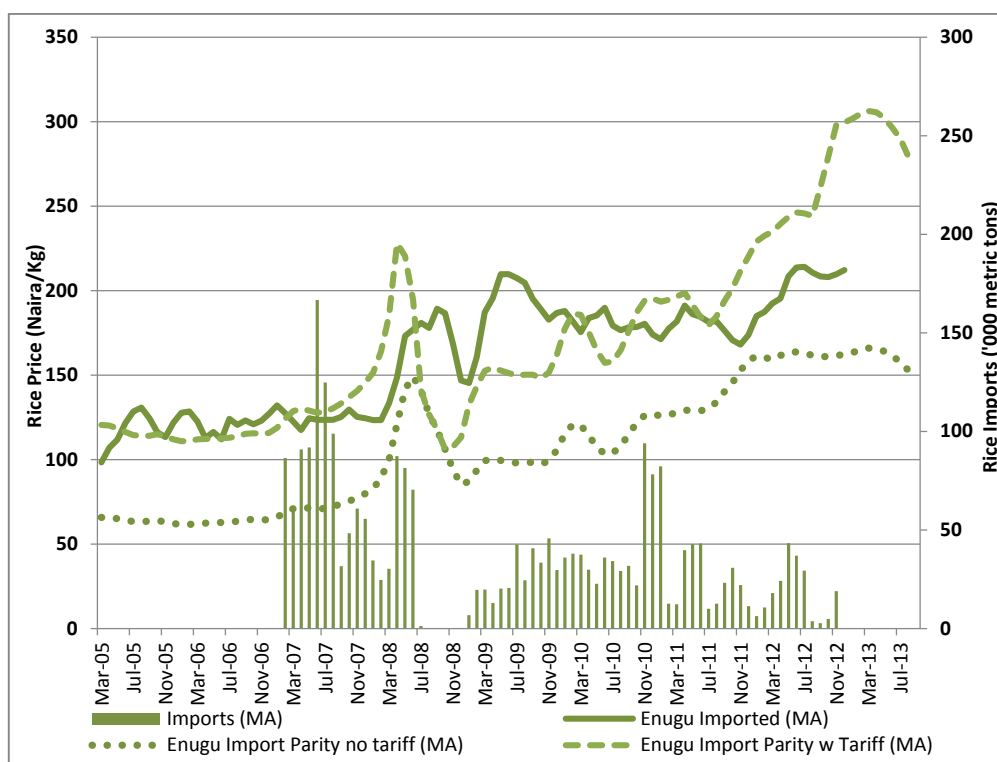
FAO data on annual rice imports into Nigeria suggest that they have increased by approximately 1 million tons per year each decade since 1970 (FAOSTAT data, [www. faostat.fao.org](http://www.faostat.fao.org)). Data on rice imports into Nigeria is especially uncertain, however. Official customs data indicate that rice imports averaged 384 thousand tons per year from 2009 through 2011. The UN Comtrade database on total exports of rice to Nigeria for these years indicate that Nigeria's imports were five times larger (1.916 million tons). Customs data on tariff payments are broadly consistent with the official tariff rate schedules – that is, it appears that most imports that are recorded by customs are charged the official tariff rates.

Nigeria has adjusted its rice tariff rate numerous times in recent years. From 2005 to mid-2007, a 100 percent tariff was imposed on rice imports. During this period, import parity prices that include the import tariff and any other costs of importing to the local market were broadly stable (Figure 1). International rice prices rose sharply in 2007 and 2008, as did wheat and maize prices, especially following restrictions on rice exports by India and Vietnam that reduced supplies on the global market. In order to prevent a large increase in domestic prices of rice, Nigeria reduced its rice import tariff to zero in April 2008.

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<sup>1</sup> Note that there is substantial uncertainty regarding agricultural production data in Nigeria, and figures vary considerably by data source.

**Figure I—Nigeria domestic and import parity rice prices and rice imports: 2005-2013**



Source: Dorosh and Malek (forthcoming) using Nigerian Bureau of Statistics import data.

Notes: MA = moving average. Data are three month lagged moving averages. Monthly import data is unavailable for 2005, 2006 and 2013. The choice of Enugu here was for illustrative purposes of a domestic market not at the port of entry for rice imports. “Enugu Imported (MA)” is the observed domestic market price of imported rice in Enugu, while “Enugu Import Parity w Tariff (MA)” and “Enugu Import Parity no Tariff” is the cost of imported rice in Enugu, with and without tariff, respectively.

The rice import parity price dropped below N 130 (Nigerian naira) per kg by June 2008, while domestic prices remained high. Imports thus appear to have been constrained during the period from mid-2008 through late 2009, a time when there were no official trade restrictions. The large gap between import parity prices and domestic prices suggests that there were substantial excess profits (rents) being obtained in this period. By early 2010, import parity prices at Enugu had risen and were again approximately equal to the domestic price through the end of 2011. Import tariff rates from 2009 through 2011 averaged 60 percent, but estimated average tariffs collected, adjusting for the gap between the official Nigerian and the Comtrade data on rice exports to Nigeria, averaged only 12 percent of import value (Table 2).

**Table 2—Nigeria rice imports, tariffs, and market prices for imported rice, 2008-13**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Cost and freight (C&F) Lagos, \$/ton	Implicit Ad Valorem Tariff Rate, %	Official / Total Imports, %	Average Effective Tariff Rate on Total Rice Imports, %	Parity Price (no tariff), naira/kg	Parity Price (w/tariff) at Enugu, naira/kg	Actual Price at Enugu, naira/kg	Nominal Rate of Protection (NRP), (7)/(5)-1	% Difference between Actual and Parity Price (w/tariff) (7)/(6)-1
2008	550.2	44	18	8	112.9	156.6	161.6	43	3
2009	373.4	64	17	11	100.5	183.8	194.7	94	6
2010	430.0	64	28	18	116.4	126.1	179.4	54	42
2011	508.2	52	12	6	138.9	182.0	179.1	29	-2
2012	583.9	72	10	8	162.1	261.6	206.7	28	-21
2013	577.5	110	--	--	162.1	298.4	--	--	--
Avg. 2009-11	437.2	60	19	12	118.6	164.0	184.4	55	12
Jan-Aug 2012	581.8	58	--	--	161.3	241.2	204.3	27	-15
Sept-Dec 2012	588.1	100	--	--	163.6	302.4	211.5	29	-30

Source: Authors' calculations based on NBS and Comtrade data.

Notes: The figures indicate a very low rate of official tariff collection. However, the high prices in retail markets suggest substantial rents were obtained, possibly including unofficial payments.

- (1) C&F Lagos is calculated as 5 percent Thai broken rice plus \$44.28/ton freight costs (Anderson (2009) data files).
- (2) The implicit ad valorem tariff is based on monthly data of import tariffs collected and declared customs values (2008-11) and on official tariff rates (2012-13).
- (3) Calculated from NBS and Comtrade data.
- (4) Average rate of tariffs is the estimated total revenues (implicit average tariff x official imports) / total (USDA est.) rice imports.
- (5) Parity price with no tariff at Enugu is calculated as [C&F Lagos + port handling charges, transport and marketing costs to Enugu] x (1 + 50 percent retail margin)
- (6) Parity price w/tariff at Enugu is calculated as [C&F Lagos + tariffs + port handling charges, transport and marketing costs to Enugu] x (1 + 50 percent retail margin)
- (7) The NRP Enugu imported rice is calculated as [(actual retail price / imported parity price with no tariff) - 1]
- (8) The percent difference between the actual retail price (7) and the imported parity price w/tariff (6).

Thus, data on rice prices and tariff collection suggest that rice import tariffs are not effectively enforced and have only a muted effect on prices, at best. Nonetheless, these tariff policies may have significant effects on incentives for rice millers and large importers, some of whom may pay tariffs or face other costs associated with rents arising from tariff evasion. In this case, the rice trade policy may actually play a significant role in promoting industrialization using the 'infant industry' argument.<sup>2</sup> The practical challenge for Nigerian policy makers, however, is selecting an optimal tariff rate for rice that can still benefit society overall even when faced with the threat of smuggling. This means selecting a tariff rate that is not only effective at helping to reduce some imports while promoting local production, but can minimize any resulting net social welfare losses from rising prices and public sector costs associated with managing the tariff, e.g., lost revenues from tariff evasion or costs associated with smuggling prevention. Additionally, producer and consumer welfare is likely to vary widely across Nigeria given varying supply and demand dynamics, including between urban and rural areas, as a result of rising tariffs on import flows through both official and non-official channels. The objective of this paper is to analyze whether such an optimal rice import tariff exists for Nigeria, especially given the potential for smuggling and the varied welfare implications for consumers and producers across different locations.

<sup>2</sup> The role of trade policy in development has long been debated, particularly whether trade liberalization or import restrictive policies are effective for promoting industrialization and growth (Krueger 1997). Many have argued that trade liberalization may not be the best policy due to uncertainty in global prices (Jabara and Thompson 1982), or domestic capital and labor market failures as in the 'infant industry argument' (Krueger 1997).

### 3. THE SPATIAL MULTIMARKET RICE MODEL AND DATA SOURCES

In this paper, we use a spatial equilibrium model in the tradition of Takayama and Judge (1964), Harker (1986) and others. These models were originally cast as simple transportation problems and solved using linear programming optimization routines involving minimization of transportation costs between regions given prices and excess supply and demand, or maximizing social welfare (net producer and consumer surplus) subject to transportation cost and the usual demand and supply constraints.<sup>3</sup>

A number of situations have been shown to be more ideal for using complementarity programming. For example, when considering ad-valorem taxes (e.g. on transport), tariffs on trade with the rest of the world, and other quantitative restrictions, as noted by Arndt & Schiller (2000). For ad-valorem taxes, Rutherford (1995) argues, for example, that the resulting solution using a nonlinear programming approach can be quite inefficient as it would require solving a sequence of nonlinear programs. The complementarity formulation on the other hand is straightforward and more transparent. For investment models, Takayama and Hashimbo (1984) also highlight some advantages of Linear Complementarity Programming models as having a more direct mechanism to solve for regional market demand quantities that are consistent with market prices, or when supplies are fixed, and overall, tend to respond more smoothly to continuous parameter shocks.

A key advantage of using the complementarity programming approach for our purposes is that Karush-Kuhn-Tucker conditions (KKT) conditions can be easily applied with direct economic interpretations arising from them. In the process, this has the added advantage of making the problem transparently clear on how it solves for an optimum solution when considering price responsive supply and demand equations (Rutherford, 1995), as we do in this study.

Mathematically, a generalized form of the spatial equilibrium problem is typically solved as a non-linear optimization problem which maximizes net social welfare subject to transportation costs, a world price for imports, and local supply and demand constraints. Net social welfare benefits are measured as the integrals of the inverse demand and supply functions.<sup>4</sup> By taking the first order conditions and using the KKT conditions for a local maximum, the problem can be converted into its complementarity expression as a system of relational inequalities and complementarity variables.

Using this general specification of the complementarity problem, a two-commodity spatial equilibrium rice model is developed for Nigeria to simulate two distinctive rice commodities in all of its 47 states and in two types of markets, rural and urban. The commodities are a standard and a premium rice variety. The standard variety is of poorer quality, produced locally, and marketed as loose grain. The premium variety represents either an imported variety from world markets or a locally produced variety processed by large scale millers. The locally produced premium rice is of a much higher quality than standard rice and is packaged and marketed as a branded product. The two varieties are imperfect substitutes with the standard variety more popularly consumed by poorer households and in rural areas, as it is cheaper in price.

Trade between regions occurs when the price difference between them reaches the full cost of transporting goods between the regions. Similarly, commodities are imported when the wholesale price in a region rises as high as the import parity price for that region; they are exported when the price falls as low as the region's export parity price. Because Nigeria is an importer that accounts for only 7 percent of world rice imports, we assume the country is a 'small country' and cannot influence the world price. In other words the world rice price is considered an exogenous variable in the model. Imports are allowed to enter two ports in two states, respectively. The first is

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<sup>3</sup> As Rutherford (1995) would show later, the simple linear programming problem could be translated into a complementarity one. This was desirable under certain conditions when the use of linear or non-linear programming approaches proved less efficient.

<sup>4</sup> This is really the net of consumer and producer surplus.

via Lagos in the South, which is considered the principal port for which an effective import tariff can be successfully introduced. The second is via Kano in the North, for which unofficial imports can enter via the free port of Cotonou in the neighboring country of Benin.

Assuming quadratic demand and supply functions:  $(Q_{kj}^d)$  in a region  $j$  and  $(Q_{ki}^s)$  for region  $i$  for commodity  $k$  ( $k = 1, 2$ ), and allowing for some limited cross-price effects, these and their complementarity variables are represented in the model as:<sup>5</sup>

$$Q_{kj}^d(P_{kj}) = \alpha_{kj} - \sum_l \beta_{lj} P_{lj}, \perp Q_{kj}^d \geq 0 \forall i, j \in N, \forall k, l = 1, 2 \quad (1)$$

$$Q_{ki}^s(P_{ki}) = \gamma_{ki} + \sum_l \delta_{li} P_{li}, \perp Q_{ki}^s \geq 0 \forall i, j \in N, \forall k, l = 1, 2 \quad (2)$$

Where  $l$  is an alias of commodity  $k$  (i.e.  $l = 1, 2$ ) to allow for cross-price effects,  $\alpha_{kj}$  and  $\gamma_{ki}$  are intercepts, and  $\beta_{kj}$  and  $\delta_{ki}$ , are slope parameters for demand and supply curves of commodity  $k$  ( $k = 1, 2$ ), with  $\beta_{kj} < 0$  and  $\delta_{ki} > 0$ . Equilibrium conditions for excess supply and demand determine the equilibrium prices of each commodity within each region, as follows:<sup>6</sup>

$$Q_{ki}^d|_{k=1} = Q_{ki}^s + \sum_{i=1}^N \sum_{j=1}^N (X_{kji} - X_{kij}), \perp P_{kj} \geq 0, \forall ij \in N, \forall k = 1 \quad (3)$$

$$Q_{ki}^d|_{k=2} = Q_{ki}^s + M_{ki} + \sum_{i=1}^N \sum_{j=1}^N (X_{kji} - X_{kij}), \perp P_{ki} \geq 0, \forall ij \in N, \forall k = 2 \quad (4)$$

As before, the variable  $X_{kij}$  represents trade flows between regions for each commodity, i.e. the quantities of commodity  $k$  that is transported between a supply region  $i$  and a demand region  $j$ . These are constrained as positive, i.e. commodity  $k$  can only be transported in one direction at each given time.  $M_{ki}$  represents imports of the premium commodity ( $k = 2$ ). Both  $X_{kij}$  and  $M_{ki}$  are determined separately by the price relationships in equations (5) and (6) below, respectively.

As market equilibrium conditions, equations (3) and (4) express the requirement that supply quantities of commodity 1 and 2 shipped between regions has to equal the quantity demanded in the region receiving the commodity. Similarly, the quantity shipped out by a region cannot be more than what is available in the region to ship, less any quantities demanded locally. Both equations determine the equilibrium prices for each commodity type,  $P_{1j}$  and  $P_{2i}$ , respectively.

Now, given transportation and marketing costs,  $c_{ij}$  (again using the same notation as in the general case for either commodity), we can now determine the trade flows ( $X_{kij}$ ) between regions. As the complementarity variable here, it is determined by the price differential between regions, inclusive of transportation and marketing costs ( $c_{ij}$ ):

$$P_{ki} + c_{ij} = P_{kj}, \perp X_{kij} \geq 0 \quad (5)$$

Furthermore, since we have added the option for importing commodity 2, premium rice, from world markets, and we wish to add an import tariff ( $\tau_i$ ) plus an optional transportation or freight cost ( $\alpha_i$ ) for any imports diverted to another port to evade the tariff, we can express this price relationship as follows:<sup>7</sup>

<sup>5</sup> An additional subscript not shown here is the disaggregation of regions  $i$  and  $j$  by rural and urban. This was purposefully left out simply to avoid complicating the presentation. These can be treated the same way as the regions – except now with higher matrix dimensions of the regions as trade can also occur between rural and urban areas across states.

<sup>6</sup> This is really combining equations (1) and (2) from the more general specification of the spatial equilibrium model.

<sup>7</sup> An unconventional aspect here is the option to import through non-official channels to avoid the import tariff ( $\tau_i$ ), but with an added freight cost ( $\alpha_i$ ) to divert the imports.

$$\bar{p}_{2i^{a,b}}^w(1 + \tau_{i^a}) + \alpha_{i^b} \geq P_{2i^{a,b}}, \perp M_{2i} \geq 0 \quad i^a = \text{Lagos}, i^b = \text{Kano} \quad (6)$$

Here  $\bar{p}_{2i^{a,b}}^w$  is the world price at either of the two ports for world imports ( $a = \text{Lagos}$ ;  $b = \text{Kano}$ ), including any port handling charges and fees. This is prior to adding costs of the tariff (at Lagos) and freight costs to evade the tariff (at Kano). For Kano in the northern part of Nigeria, imports are assumed to initially enter through the free port of Cotonou in Benin and then transported overland through Benin and Niger before entering Kano in Nigeria. Equation (6), therefore, is specifically designed to determine the optimal volume of imports from world markets and at which port depending on the final price differential between the two ports given the values of  $\tau_i$  and  $\alpha_i$ . Simply put, if  $\bar{p}_{2i^a}^w(1 + \tau_{i^a}) + c_{i^a j} \geq \bar{p}_{2i^b}^w + \alpha_{i^b} + c_{i^b j}$  in market  $j$ , then imports to this market would originate from through Kano.

Finally, in simultaneously solving for the sequence of equations and complementarity relationships in equations (1) through (6), an optimal solution in the variables,  $Q_{kj}^d, Q_{ki}^s, X_{ijk}, M_{2i}$  can be determined, inclusive of regional disaggregation by rural and urban areas. Results are aggregated across six geo-political regions among the 47 states of Nigeria (Appendix Table A.5).

The data for model parameters and validation are based on various secondary sources and the field work of the authors. Production data was taken from the National Agricultural Extension and Research Liaison Services (NAERLS) of 2009; demand data at the regional level was from the Consumption Patterns in Nigeria, 2009/10 data set of the National Bureau of Statistics (NBS), adjusted by population statistics; and prices were also from the NBS for 2012 and 2010 for both local and imported rice. Nigerian government documents were relied on to define the country's national objectives and targets for improving the rice sector.

Price elasticities used in the model were taken from various sources. The own-price elasticities of demand for both types of commodities (standard and premium rice) and for urban and rural areas were from Gyimah-Brempong and Kuku (forthcoming).<sup>8</sup> These are presented in Appendix Table A.1. The cross-price elasticities in Table A.1 were derived from demand shares of each type of rice to total rice consumed at the national level in urban and rural areas and the own price elasticities. We chose to include these to allow for some substitutability between the two types of rice rather than assuming away any cross-price effects. Own price elasticities of supply for local standard rice was assumed to be 0.2 as in Diao, Johnson, and Takeshima (forthcoming) and the review by Rahji and Adewumi (2008). For domestic premium rice, a value of 0.8 was used considering that large scale millers use their existing capacities to mill imported brown rice if local paddy rice is unavailable in order to meet demand (Johnson, forthcoming). Appendix Table A.2 presents the values of own and cross price elasticities of supply used. Because of uncertainties surrounding parameter values of elasticity estimates, we adjust these later in section 5 to test the sensitivity of the model to any changes in these parameter values.

For freight and transportation costs, these were calculated using unit costs and actual distances in km between state capitals. Average unit freight costs by the six geopolitical zones are presented in Appendix Table A.3. For freight costs to import rice via Kano, this is based on the overland distance by road from the port of Cotonou in Benin to Kano via Niger (a total distance of 1,684 km) and a unit transportation cost that is assumed to be 50 percent more than in the southern parts of Nigeria from the port of Lagos – 33.71 Naira/mt/kg. This is inclusive of higher petrol costs (about 20 percent higher according to globalpetrolprices.com) and an additional 30 percent for smuggling transaction costs.

Due to the unavailability of sufficient data for rural and urban marketing costs, these were weighted by distances between states and whether trade is urban to urban, urban to rural, rural to urban, or rural to rural. The choice of using distance related costs was to distinguish cost differences in marketing in each state based on

<sup>8</sup> Although Gyimah-Brempong and Kuku (forthcoming) publish estimates at the national level only, the authors were able to obtain disaggregated estimates when sufficient data was available using their Linear Expenditure System (LES) regression model. This was done at the geopolitical region as displayed in Table A.5 in the Appendix.

source and destination. Within each state, additional costs were added to distinguish between rural or urban in either direction (assumed to be asymmetric – with higher costs for rural marketing). These marketing costs are presented by geopolitical zone in Appendix Table A.4. For the Northeast (NE) geopolitical zone, costs are doubled to account for its relative isolation, given the current adverse security situation, while in the Southwest (SW) zone, costs are assumed to be much lower at 70 percent below calculated values. Later in Section 5, we also adjust the overland freight and rural marketing costs separately to test for the sensitivity of model results in terms of the range of tariff rates at which all imports will shift from Lagos to Kano.

The model is calibrated to reflect Nigerian rice markets in 2009. Because a tariff rate of 40 percent existed at the time, the base model was calibrated to closely resemble actual observed values at the time with respect to quantities demanded and supplied, including import volumes. Final prices determined by the base model were also checked for their reasonableness based on observed prices for which data was available for 2009. Table 3 presents the final base model results as compared with actual values of total demand, supply, and import quantities for both types of rice commodities. With the exception of domestic premium rice production, the model validation is reasonable for the base case scenario, with a percentage difference between observed values and base model results ranging between 1.0 to 5.1 percent in absolute terms for each of the key endogenous variables.

**Table 3—Comparing base model results with observed quantities of demand (rural and urban), production, imports and total supply, by type of rice, thousands of mt**

	Observed	Base Model	Percent difference
<b>Demand (,000 metric tons)</b>			
Standard, Rural	2,226	2,322	4.3
Standard, Urban	583	556	-4.5
Premium, Rural	1,198	1,137	-5.1
Premium, Urban	1,359	1,417	4.3
<b>Production (,000 metric tons)</b>			
Local standard	2,808	2,878	2.5
Local premium	749	713	-4.8
Total rice	3,557	3,591	1.0
<b>Imports (,000 metric tons)</b>			
Imported premium <sup>a</sup>	1,809	1,841	1.8
<b>Supply (,000 metric tons)</b>			
Production + imports	5,366	5,432	1.2

Source: Nigeria Spatial Rice Market Model.

Notes: <sup>a</sup> The base model results show about 7.4 percent of this amount (about 138,500 metric tons) being imported through Kano, a reasonable result considering traditional trade linkages with Niger among traders in the north.

## 4. SIMULATION RESULTS

In this section, we present model simulation results under two alternative import trade regimes:

- 1) no smuggling, in which all rice imports face import tariffs at the border (mainly Lagos port); and
- 2) cross-border smuggling through the Niger-Nigeria border near Kano.

In describing the results for each trade regime, we first discuss national level results, and then describe the regional effects within Nigeria of tariff policies under these alternative trade regimes.

### 4.1 Effects of Tariff Changes with No Smuggling

In the no smuggling scenario, increasing rice tariffs results directly in corresponding increases in imported rice prices and a reductions in imports (Table 4). At a zero tariff, imports reach 3.2 million tons with rising demand as

prices fall, almost double the level in the base case (40 percent tariff). Imports do not entirely displace local production, however, as prices for local varieties in some of the more distant markets would still remain competitive with imports coming from Lagos, given high transportation and marketing costs for imported rice.

**Table 4—Production, consumption, imports and prices of premium and standard rice by tariff regime – no smuggling scenario**

Region	Premium Rice (By tariff regime)			Percent change 40 -> 120	Standard Rice (By tariff regime)			Percent change 40 -> 120
	0	40*	120		0	40*	120	
<b>Consumption</b> (,000 metric tons)								
Central	512	347	190	-45.3	206	455	687	51.2
North	1,200	869	589	-32.2	886	1,256	1,560	24.2
South	2,331	1,326	235	-82.3	524	1,185	1,892	59.6
<b>National</b>	<b>4,043</b>	<b>2,541</b>	<b>1,014</b>	<b>-60.1</b>	<b>1,617</b>	<b>2,896</b>	<b>4,139</b>	<b>42.9</b>
<b>Production</b> (,000 metric tons)								
Central	70	159	233	46.6	565	918	1,262	37.5
North	188	338	481	42.1	1,006	1,616	2,199	36.0
South	144	224	300	34.2	46	362	679	87.6
<b>National</b>	<b>401</b>	<b>721</b>	<b>1,014</b>	<b>40.6</b>	<b>1,617</b>	<b>2,896</b>	<b>4,139</b>	<b>42.9</b>
<b>Imports</b> (,000 metric tons)								
<b>Via Lagos</b>	<b>3,641</b>	<b>1,820</b>	<b>0</b>	<b>-100.0</b>	NA	NA	NA	NA
<b>Average Urban Prices</b> (Naira/kg)								
Central	113.1	150.7	186.3	23.6	99.7	102.8	105.6	2.7
North	122.5	159.7	192.5	20.5	100.7	103.2	105.8	2.5
South	109.9	147.9	187.7	26.9	104.9	107.5	110.4	2.7
<b>National</b>	<b>114.7</b>	<b>152.5</b>	<b>189.1</b>	<b>24.0</b>	<b>102.5</b>	<b>105.1</b>	<b>107.9</b>	<b>2.6</b>
<b>Average Rural Prices</b> (Naira/kg)								
Central	127.2	165.6	202.0	22.0	87.2	90.1	92.8	3.1
North	134.7	172.2	205.0	19.0	89.8	92.3	94.8	2.7
South	122.5	160.9	200.1	24.4	100.6	103.2	106.1	2.7
<b>National</b>	<b>127.5</b>	<b>165.6</b>	<b>202.1</b>	<b>22.0</b>	<b>94.5</b>	<b>97.1</b>	<b>99.8</b>	<b>2.8</b>

Source: Nigeria Spatial Rice Market Model simulations.

Note: \* The 40 percent tariff regime is the base case scenario.

The Central region corresponds to the North Central geopolitical zone; the North region to the North West and North East zones; and the South region to the three southern geopolitical zones.

The average domestic price for premium rice in urban areas rises from about 152.5 Naira/kg when the tariff rate is 40 percent to 189.1 Naira/kg when the rate reaches 120 percent. For standard ordinary rice, prices rise, but more slowly, from 105.1 to 107.9 in urban areas and 97.1 to 99.8 in rural areas. Given higher domestic prices, domestic production rises, and imports of premium rice are gradually replaced by local premium rice, as domestic production of premium doubles from a base of 0.72 million (with 40 percent tariff) to about 1.01 million metric tons at the tariff rate of 120 percent. Production of ordinary rice increases even more from 2.9 to 4.1 million metric tons, raising total production to 5.1 million tons at tariff rates above 93 percent – equal to total domestic demand at the tariff-induced higher domestic prices – and thus achieving self-sufficiency as consumers shift towards the standard rice variety. Total demand actually falls by 300,000 metric tons, from 5.4 million metric tons.

How prices change by location, whether urban or rural, as a result of import tariff policies will vary and have important implications on production and demand for each type of rice. Referring back to Table 4, as import tariffs for premium rice are raised from the base of 40 percent to 120 percent, domestic prices for this variety rise by 24.0 percent nationally in urban areas (which has the greatest demand) and 22.0 percent in rural areas. The lower rise in prices in rural areas reflect the fact that prices are already higher in rural areas due to transport and marketing costs, so a proportional effect of a change in tariff is smaller since these margins are only affected by

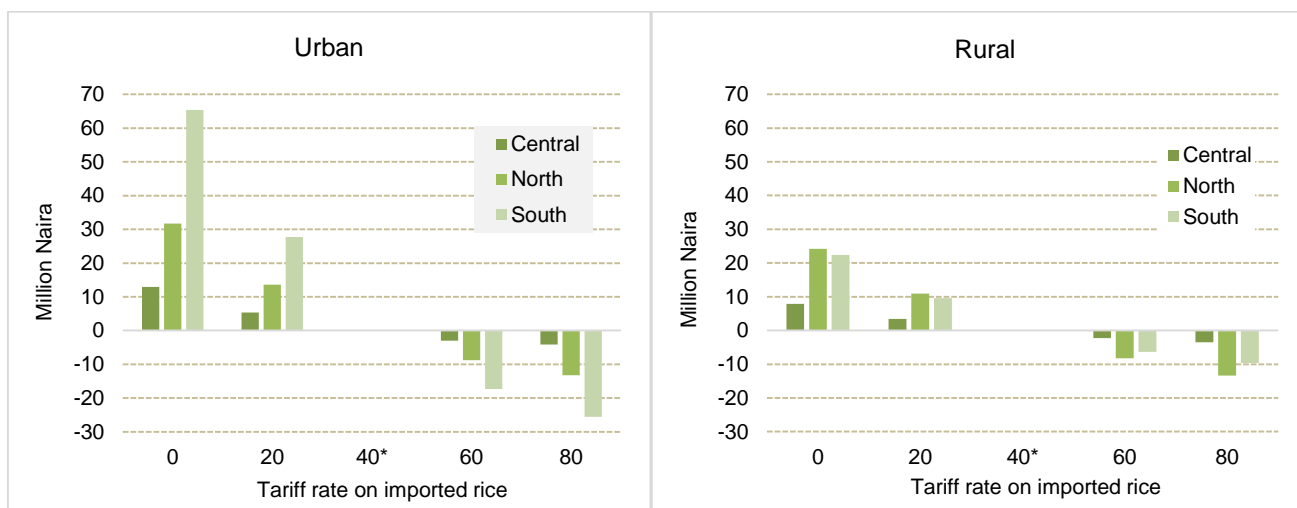
the volume traded. Additionally, consumers in rural areas are more likely than urban consumers to shift to local standard rice varieties.

There are also differences between the Central, North, and South regions, as one would expect. Urban prices actually rise slightly less in the North than in the South, 20.5 percent versus almost 26.9 percent in the South. The Central region experiences a decline of 23.6 percent. This is because both the Central and the North supply a significant amount of locally produced premium rice (especially in Kano) to the Central region, while the South relies more on imports from the North or the world market. Rural prices follow similar patterns, although with lower price changes relative to urban areas. This is primarily due to the fixed higher transportation and marketing costs not directly affected by tariffs. Finally, given the assumption of weak substitution between the two types of rice, prices for standard rice rise only marginally relative to premium rice on which the tariff is directly targeted (a change of about 2.5 to 3.1 percent). The small change in price is also quite similar across all regions and in rural or urban areas.

The impact on production is obviously affected by the effect of the tariff on prices and subsequently demand, all of which vary by location. Prices for standard rice rise marginally with higher tariffs. This can be explained by the increase in demand as some consumers switch from premium rice in favor of the cheaper standard variety. At the higher tariff rate, demand for premium rice declines by 60 percent, while it increases for standard rice by 42 percent. Much of the substitution occurs in the south as the region has more to lose when prices rise with higher tariffs.

These changing patterns of quantity demanded and equilibrium prices for each type of rice has important implications for household welfare, whether in rural or urban areas. For example, the decline in demand for premium rice as prices rise hurts urban households the most, as they are the least likely group of consumers to substitute towards the cheaper standard variety. Only producers of the premium variety – large scale millers in urban areas – benefit. In rural areas, on the other hand, the shift by a majority of consumers towards buying the cheaper standard rice alternative lessens the overall negative impact of the higher tariff on rural welfare relative to urban areas, and even more so if they are many net sellers of standard rice. Figure 2 shows the change in net social welfare across geographic regions and urban or rural areas as tariffs are raised. Because the South is mostly made up of net buyers, this is the region most likely to lose on net with higher prices – and even more so in urban areas. Notice in Figure 2 the much higher welfare changes for the urban versus the rural population in the South region compared with the other two regions.

**Figure 2— Change in net producer and consumer welfare in rural and urban areas due to tariff changes, no smuggling scenario, for all rice, million Naira**



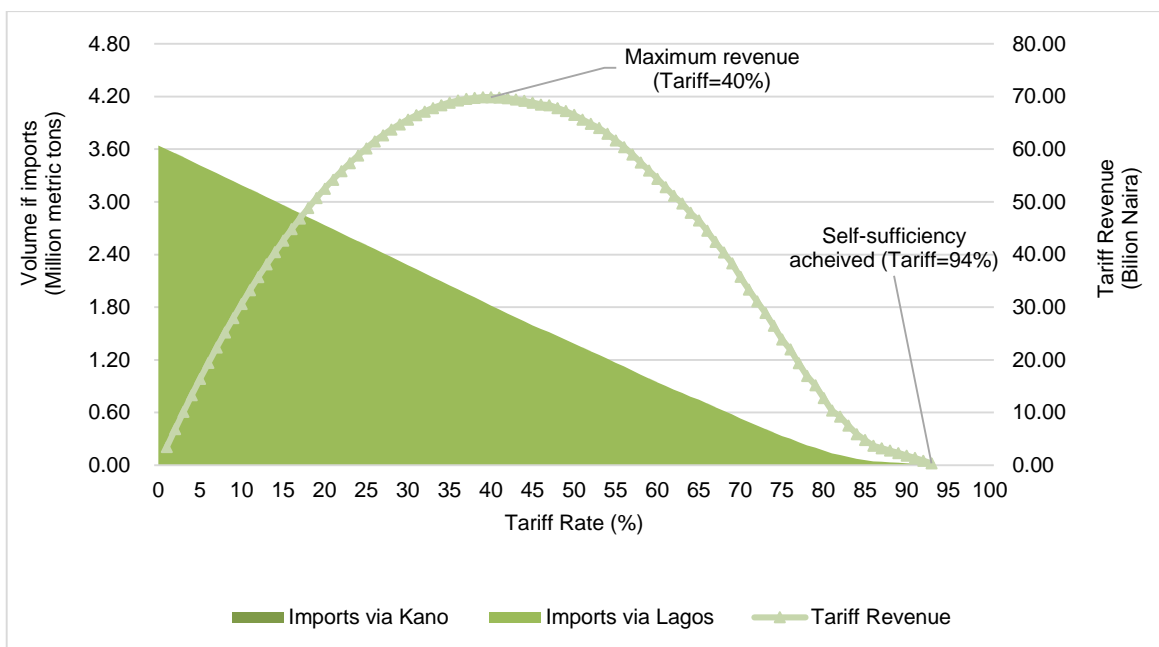
Source: Model results

Note: \* The initial tariff rate was 40 percent, hence the absence of any change in welfare at this tariff level.

Among urban consumers, poorer households suffer the most as they rely on a much higher proportion of their income for food purchases. In the major rice producing regions in the Central and North regions, the net effect on rural and urban welfare is about the same, as both areas produce rice – the standard variety in rural areas and premium rice in urban areas. The majority of beneficiaries in rural areas will be the net sellers, the rice paddy farmers and small scale millers. The increase in demand and prices of the local standard variety, as consumers shift away from the more expensive premium variety, stimulates this sector to produce more.

Finally, considering the tariff rates at which government can maximize tariff revenues or achieve the self-sufficiency policy goal under our scenario with no smuggling (all imports pass through Lagos), these are 40 percent and 94 percent, respectively (Figure 3). Beyond the 40 percent mark, any further increases in tariffs reduces demand for rice imports by a greater percentage than the percentage increase in tariffs. Although the country can achieve the self-sufficiency goal at the tariff rate of 94 percent, this occurs at the expense of consumer welfare, as pointed out earlier.

**Figure 3—Total imports and tariff revenues – no smuggling scenario**



Source: Nigeria Spatial Rice Market Model simulation results.

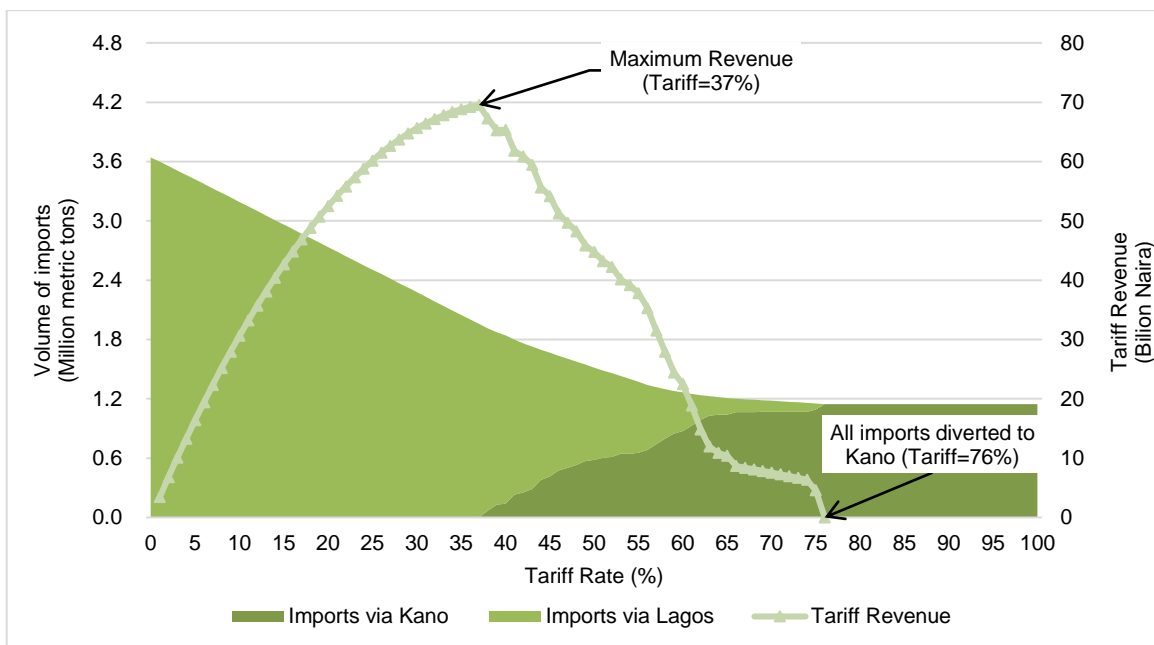
## 4.2 Effects of Tariff Changes with Smuggling

So far we have considered the situation where a tariff policy is completely effective and official rice import channels are used, i.e., all imports pass through Lagos and are reported. We now introduce the option to divert imports through Kano, a channel that avoids the tariff, but requires rice smugglers using this route to import rice to pay higher freight costs to ship over land through Benin and Niger. We also look at trade flows between regions in Nigeria, comparing both scenarios of with and without smuggling. At some point, as tariffs rise, even with the more costly shipping channel that avoids tariffs through Benin and Niger, an import parity price will result in Kano that is lower than that of the rice imported via Lagos. Based on information obtained through field observations, this is a situation that was close to the reality in Nigeria in 2013 when tariff rates had increased to 110 percent.

Figure 4 presents the volume of imports through both Lagos and Kano. Initially at the 40 percent base tariff, Kano already imports a small amount of premium rice from world markets, but very small amounts. Evidently, a 37 percent tariff proves to be a critical point when the cost of importing through Kano is now about equal with that of Lagos (the costs of the former mostly in land transportation and marketing costs via Benin and Niger, and

the costs of the latter affected by the tariff and land transportation and marketing from the south to north in Nigeria). With smuggling, it is at rice tariffs higher than 37 percent that tariff revenues begin to fall significantly relative to the scenario when there is no smuggling. The import share of total rice consumed in Nigeria at this tariff threshold would be 36 percent. At the 76 percent tariff rate, all imports come through Kano and tariff revenues fall to zero. In the end, with smuggling Nigeria is only able to attain a self-sufficiency ratio of about 78 percent, and therefore, unable to achieve its self-sufficiency policy goal in rice production. In other words, Nigeria would still have to import about 22 percent of its rice consumption needs.

**Figure 4—Total imports via Kano and Lagos, and tariff revenues – smuggling scenario**



Source: Nigeria Spatial Rice Market Model simulation results.

As in Table 4 earlier, Table 5 presents for the smuggling scenario a breakdown of production, consumption, imports, and prices by region for both premium and standard rice. As before, imports are partially replaced by increased production of local premium rice as prices rise, an increase of 12 percent (713,000 to 802,000 metric tons) at the 76 percent and higher tariff rates (also see Figure 4). Total demand decreases less for premium rice than without smuggling as prices are maintained at lower levels due to smuggling. This time, the substitution away from premium to standard does not occur as much. Evidently, the smaller rise in premium prices causes fewer premium rice consumers to shift towards the cheaper standard rice variety.

With respect to prices, as import tariffs for premium rice rise from the base of 40 percent to 120 percent (or at the threshold of 76 percent above when tariffs are no longer effective), domestic prices for premium rice in urban areas rise by only about 7.5 percent relative to the 24 percent seen in the no smuggling scenario. However, the South region experiences far greater increases in price (12.3 percent) relative to the North (only 1.7 percent) and Central regions (6.8 percent), especially when tariffs rise above 76 percent and all imports come through Kano. The difference captures the greater transporting and marketing costs associated with moving imported rice through Kano to markets in the south. A similar trend occurs in rural areas, but at much higher prices.

There is only a marginal effects on the price for standard rice in all regions – about a 3 percent increase – under the smuggling scenario. The smaller price changes for premium rice in the North region are expected as imports flow through Kano in the north, together with a greater capacity for milling of local premium rice. The additional cost of transporting and marketing this rice to the South region explains the higher rate of price increases

in the South, as prices are initially lower there. Naturally, the only exception is when tariffs are removed altogether – which would be equivalent to the alternative scenario considered of no smuggling.

**Table 5—Production, consumption, imports and prices of premium and standard rice by tariff regime – with smuggling scenario**

Region	Premium Rice (By tariff regime)			Percent change 40 -> 120	Standard Rice (By tariff regime)			Percent change 40 -> 120
	0	40 <sup>a</sup>	120		0	40 <sup>a</sup>	120	
<i>Consumption</i> (,000 metric tons)								
Central	512	349	311	-10.9	206	451	498	10.3
North	1,200	879	880	0.1	886	1,241	1,225	-1.4
South	2,331	1,327	759	-42.8	524	1,185	1,516	27.9
<b>National</b>	<b>4,043</b>	<b>2,554</b>	<b>1,949</b>	<b>-23.7</b>	<b>1,617</b>	<b>2,878</b>	<b>3,238</b>	<b>12.5</b>
<i>Production</i> (,000 metric tons)								
Central	70	158	183	16.4	565	915	1,028	12.3
North	188	334	365	9.3	1,006	1,601	1,721	7.5
South	144	222	254	14.5	46	362	489	35.4
<b>National</b>	<b>401</b>	<b>713</b>	<b>802</b>	<b>12.5</b>	<b>1,617</b>	<b>2,878</b>	<b>3,238</b>	<b>12.5</b>
<i>Imports</i> (,000 metric tons)								
<b>Imports via Lagos</b>	<b>3,641</b>	<b>1,702</b>	<b>0</b>	<b>-100.0</b>	NA	NA	NA	NA
<b>Imports via Kano</b>	<b>0</b>	<b>139</b>	<b>1,147</b>	<b>724.5</b>	NA	NA	NA	NA
<i>Average Urban Prices</i> (Naira/kg)								
Central	113	150	161	6.8	100	103	104	1.2
North	122	159	162	1.7	101	103	104	1.0
South	110	148	166	12.3	105	108	109	1.3
<b>National</b>	<b>115</b>	<b>152</b>	<b>163</b>	<b>7.5</b>	<b>102</b>	<b>105</b>	<b>106</b>	<b>1.2</b>
<i>Average Rural Prices</i> (Naira/kg)								
Central	127	165	174	5.3	87	90	91	1.4
North	135	171	172	0.9	90	92	93	1.0
South	122	161	178	10.7	101	103	105	1.3
<b>National</b>	<b>128</b>	<b>165</b>	<b>175</b>	<b>6.2</b>	<b>94</b>	<b>97</b>	<b>98</b>	<b>1.2</b>

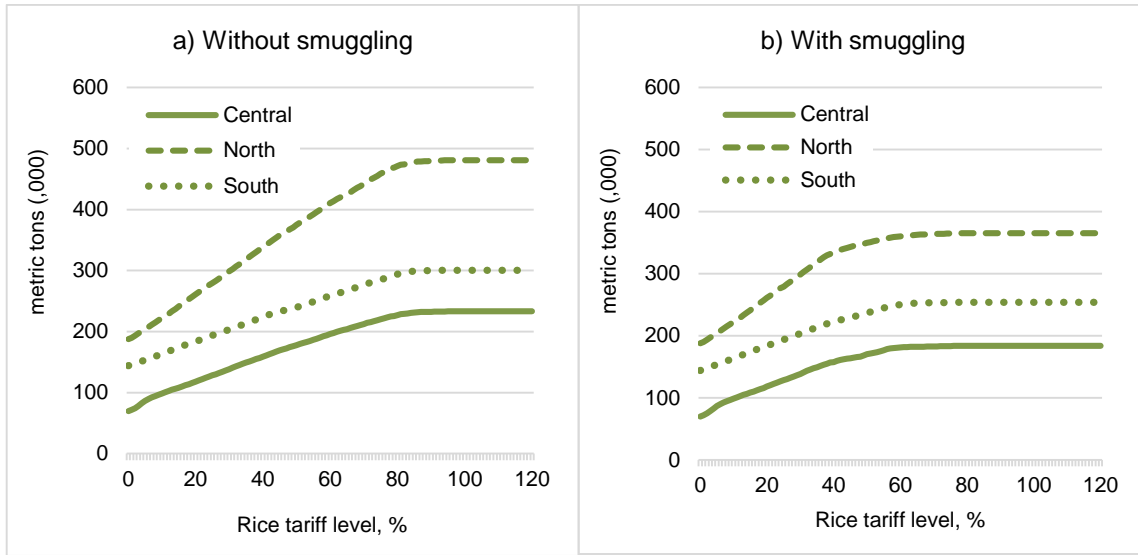
Source: Nigeria Spatial Rice Market Model simulations.

Notes: <sup>a</sup>The 40 percent tariff regime is the base case scenario. The base model results show about 7.4 percent of imports (138,500 metric tons) being imported through Kano, a reasonable result considering observed trade linkages with Niger among traders in the north.

Central region corresponds to the North Central geopolitical zone; the North region to the North West and North East zones; and the South region to the three southern geopolitical zones.

Given the reduced effect of higher tariffs on prices, production will not respond as much as it does if the tariffs were effective (without smuggling). Figure 5 shows total production of local premium rice as tariffs change under both scenarios of with and without smuggling. Higher tariffs provide greater incentives for local producers to expand output when the tariffs are effective, while a zero tariff would force many of out of business. But the size of the effect varies by regions, with production volumes in the North region increasing at more than twice the volume of the South. Rice producers in the Central region, on the other hand, responds at a slower rate despite producing a significant amount of standard local rice (and paddy rice in general). This is because farmers in the Central region produce less premium rice as the region has fewer large modern millers than the North (Johnson, forthcoming). At the same time, Central region is also better able to take advantage of any tariff evasion above the 37 percent optimal tariff by importing premium rice from the North instead of the South.

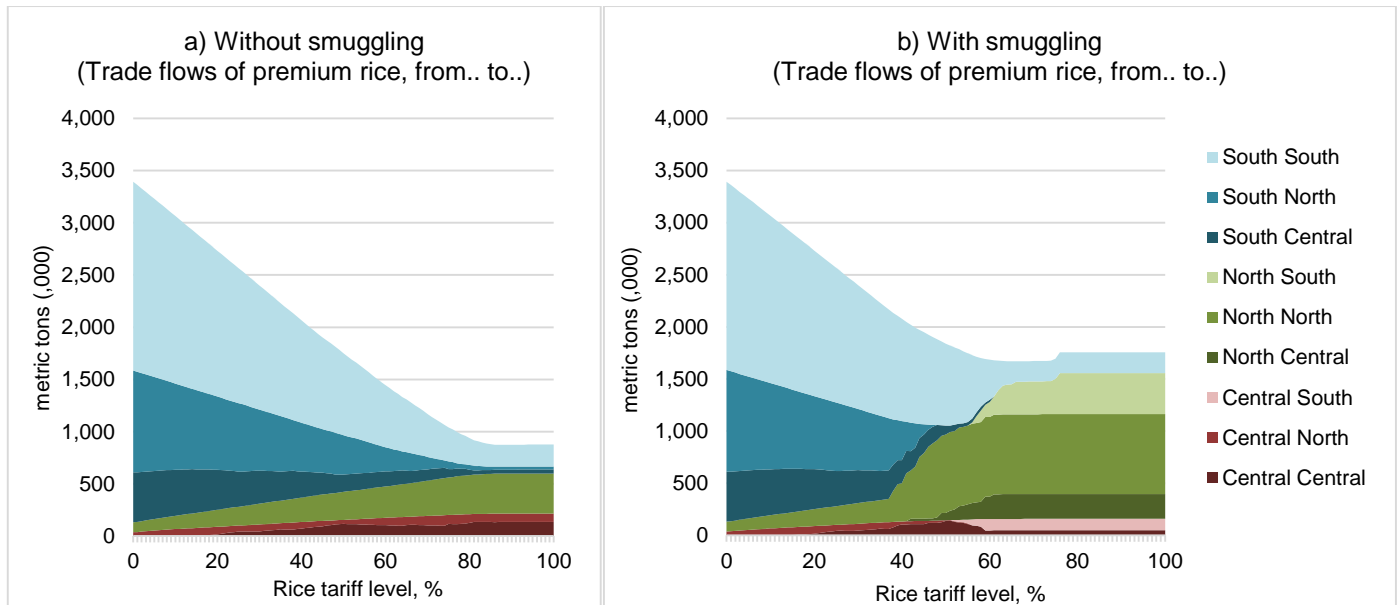
**Figure 5—Total production of local premium rice by tariff level, with and without smuggling**



Source: Nigeria Spatial Rice Market Model simulation results.

The effect of the two scenarios on the volume of premium rice transported between regions to meet demand can be quite significant, with important implications on the direction of trade, in particular for the Central region. Figure 6 presents the trade flows between regions and within states in the same region for premium rice (total of imported and locally produced) as tariffs rise under both scenarios. The totals are less than in Figures 3 and 4 because here we are only measuring the amount transported from one area to another, e.g., urban to rural within a state where it is produced or transported out of state.

**Figure 6—Volume of premium rice transported between regions as tariffs change under the with and without smuggling scenarios**



Source: Nigeria Spatial Rice Market Model simulation results.

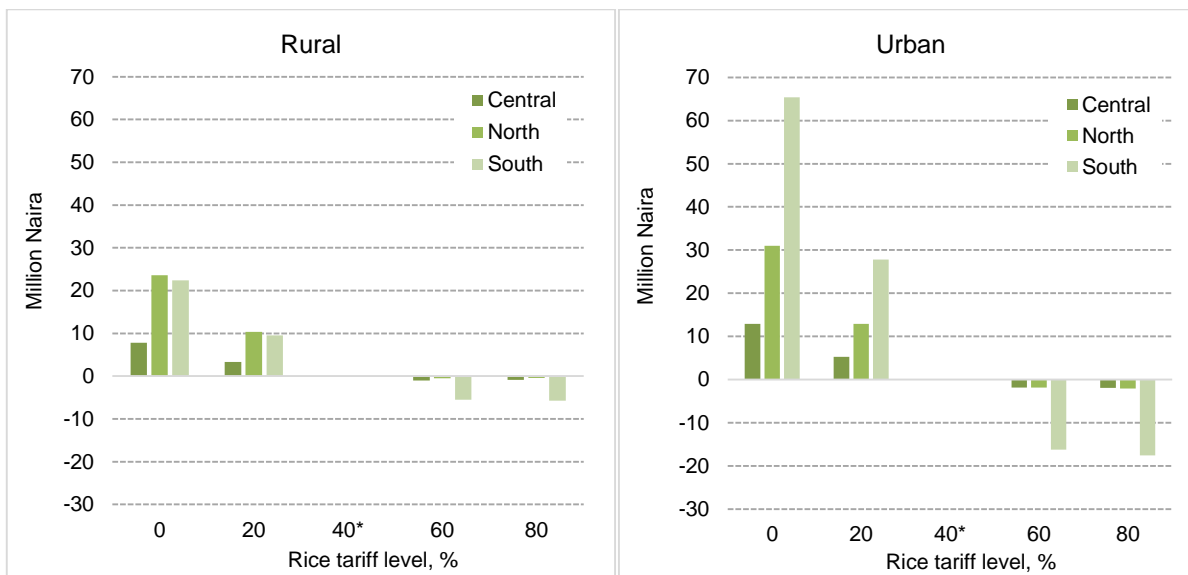
Notes: Total of imported and locally produced premium rice. The shaded portions in the figure reflect total volumes of trade flows in premium rice. In the legend category for each shaded portion, the first region is the source and the second region is the destination. If the source and destination regions are the same, this measures trade flows between states within a single region, e.g., "South South" would include trade between Lagos and Oyo states. See Appendix Table A.5 for the states in each region.

Referring to Figure 6 under the smuggling scenario, premium exports from the North increase substantially from about 37 percent until the 76 percent tariff rate is reached. This is due to excess supply in a combination of imported and locally produced premium rice. The North and Central regions combined ship over half a million metric tons of premium rice to the South at a 76 percent tariff rate, compared with none at all when all imports pass through Lagos – indeed, the flow in premium rice is the reverse when all imports come through Lagos. For standard rice (not shown here), under the smuggling scenario exports from North to South increase from 514,000 to 646,000 metric tons, a difference of about 150,000 metric tons. It is less profitable to ship rice to some areas of Nigeria since prices do not rise as much as they do when tariffs are effective. All in all, the dramatic decline in the volume of premium rice traded across regions as tariffs rise is dampened as tariffs become ineffective at 76 percent and higher, which ultimately benefits both traders and consumers alike.

An interesting result observed in Figure 6 is the increased flow of premium rice transported to the Central region from the North and the reduction in premium rice coming to the Central region from the South when tariffs fall within the range of 52 to 57 percent under the smuggling scenario. In general, the North experiences increasing volumes of trade within its region as tariffs rise above 37 percent, and then begins to export larger volumes of premium rice to the other two regions as the tariff rate continues to rise. The kink in total volumes traded at the 76 percent tariff mark occurs when all imports start coming through Kano only.

Figure 7 below presents the changes in net producer and consumer welfare in urban and rural areas with smuggling. Comparing this with Figure 2 shows how net welfare losses from rising prices are not felt as deeply as they are without smuggling, especially in the North and Central regions. However, the South still experiences relatively higher economic losses than the other two regions, as prices for premium rice rise to levels higher than in the North. Demand for rice in the South is increasingly met by transporting rice from the North.

**Figure 7—Change in net producer and consumer welfare in rural and urban areas due to tariff changes, smuggling scenario, for all rice, million Naira**



Source: Model results.

Note: \* The initial tariff rate was 40 percent, hence the absence of any change in welfare at this tariff level.

The policy goal of achieving self-sufficiency is not possible with smuggling. Even if the government can successfully curtail smuggling in order to achieve self-sufficiency by imposing higher tariff rates – 94 percent or higher according to our estimates, this would come at great costs to society. This is shown in Figure 2 with respect to declining net social welfare at higher tariff rates. Moreover, the cost to Nigeria of policing its extensive borders to curtail smuggling could be enormous, putting a drain on scarce government revenues needed to invest in the domestic rice sector in the first place. In addition, tariff revenues would disappear as rice imports dry up.

## 5. SENSITIVITY ANALYSIS

The challenge in using spatial equilibrium simulation models is ensuring that the results are credible and robust given the model's underlying assumptions and parameter values. To check for this, several simulations were conducted by changing key parameters in the model. Specifically, parameter values were both increased and reduced up to 50 percent from their initial values in increments of 10 percent. This was done under the “with smuggling” scenario. The selected parameters were:

- a) Own and cross price elasticities of demand;
- b) Own and cross price elasticities of supply;
- c) Freight and transportation costs over land (via Benin and Niger); and
- d) Internal marketing costs for intra-regional trade.

Percent root mean square errors (%RMSE) were computed to compare the results from the range of changes in each parameter value relative to the results of the model with initial values.

First, changing the values of own and cross price elasticities of demand equally across regions results in very little change in the results at any given tariff rate, aside from producer welfare in rural areas. This is most likely due to our higher cross-price elasticities of demand in rural versus urban areas. Nevertheless, it has no effect on the shifting of imports from Lagos to Kano nor on the tariff rate at which revenues or the self-sufficiency ratio is maximized. Because we are more confident of the source for the demand elasticity estimates, and considering the effects on welfare changes are limited relative to the percent changes in the elasticity values, the model is sufficiently robust with respect to these values.

For own and cross price supply elasticity values, small incremental changes were found to be less robust, resulting in some significant effects on model results. Average percent root mean square errors (%RMSE) were highest for standard rice production in the South (27.0 percent) and premium rice production in Central (13.7 percent). Producer welfare in rural areas was also significantly affected with %RMSEs ranging between 39.6 to 67.7 percent. Hardly any change occurs with regard to the tariff rate at which all imports flow through Kano, aside from the rate at which a maximum self-sufficiency ratio is achieved, which occurs at tariff rates 10 to 17 percentage points lower when compared with initial model results.

These higher sensitivities to own and cross price supply elasticity values appear primarily because of our assumptions on cross-price elasticities between standard and premium rice. A positive cross-price elasticity implies that a small change in the price of one type of rice affects the supply of the other as well. Setting them to zero results in much lower impact on the model results overall. Evidently, while the assumptions we make on cross-price elasticity values of supply are critically important for determining producer welfare and the maximum achievable self-sufficiency ratio, the model results are less affected when all import flows shift to Kano. Nevertheless, it is clear that the supply elasticities used in the model are less robust than the demand elasticities used. In order to improve the results of this model, further research is needed to estimate their correct empirical values in the case of Nigeria.

Of particular relevance to our model results is the cost of overland freight charges for rice imports flowing through Kano, as these will naturally affect the tariff rate at which imports will increasingly become diverted through the north via Kano. From Table 6, it is evident that lowering the freight costs by 50 percent dramatically reduces the tariff rate at which imports begin to flow through Kano, from 38 to 7 percent. With these lower freight costs, all imports flow through Kano at a tariff rate of 47 percent compared with the initial 76 percent. Furthermore, maximum tariff revenues occur at a lower tariff rate, 25 percent compared with 37 percent – with import shares of 50 percent. On the other hand, if freight costs are 50 percent higher, maximum tariff revenues will still occur at about 40 percent and with import shares at about 33 percent. Under these higher freight costs, the tariff rate at which all imports flow through Kano occurs at 92 percent.

**Table 6—Sensitivity of shifts in import flows via Kano by tariff rate due to changes in overland freight costs via Benin and Niger**

	Tariff level, %			%RMSE	
	Freight costs used in initial model	50% lower freight costs	50% higher freight costs	Tariff<40	Tariff>40
Tariff level at which imports begin via Kano	38	7	74	0.0	78.6
Tariff level at which all imports are via Kano	76	47	92	16.5	0.0
Tariff level at which maximum tariff revenue is achieved	37	25	40	16.9	116.6
Tariff level at which maximum self-sufficiency in rice production for Nigeria is achieved	78	47	79	n.a.	n.a.

Source: Model results.

Notes: n.a. = not applicable.

Producer and consumer welfare is also affected by our assumptions on overland freight costs, especially in the Central region, as the shift in imports from Lagos to Kano occurs at much lower tariff rates with lower freight costs or at higher tariff rates with higher freight costs (Table 7). The highly sensitive nature of the model to changes in overland freight costs for imports flowing through Kano is to be expected, as it defines the import parity price of imported rice from this source in a particular local market. If this price is lower relative to the import parity price of rice imported into this market through official channels through the port at Lagos and, hence, inclusive of the tariff, then consumers would prefer to purchase the lower priced imports coming through Kano.

**Table 7—Sensitivity of changes in demand, production, and consumer and producer welfare due to changes in overland freight costs via Benin and Niger, average percent root mean square errors (%RMSE)**

	Demand for premium rice		Production of rice		Consumer welfare		Producer welfare	
	Tariff<40	Tariff>40	Tariff<40	Tariff>40	Tariff<40	Tariff>40	Tariff<40	Tariff>40
<b>Urban</b>								
Central	1.9	19.1	2.9	16.7	40.2	-83.7	-44.5	91.0
North	3.6	16.7	4.2	17.2	65.8	-124.9	-68.2	130.8
South	0.4	35.1	1.3	11.0	16.1	-61.3	-24.3	74.4
<b>Rural</b>								
Central	2.6	22.5	1.6	12.9	45.1	-89.6	-24.8	69.4
North	4.0	17.0	3.3	14.8	69.6	-136.3	-33.0	74.4
South	1.4	44.8	2.3	24.8	26.4	-73.3	-26.0	70.2

Source: Model results

Finally, we also consider the sensitivity of our assumed marketing costs for intra-regional trade in rice. We find that at lower tariff rates urban producers of premium rice are more affected as they sell a significant portion of their rice to rural areas, a trade which is highly sensitive to transport and marketing costs. This can be observed by the greater sensitivity of rice production and producer welfare in urban areas, and overall consumer welfare in both urban and rural areas. Production of standard rice is less affected since much of it is consumed where it is produced in rural areas. The tariff rate at which import flows occur through Kano is less affected by marketing costs for rice in Nigeria.

## 6. CONCLUSIONS AND POLICY IMPLICATIONS

In Nigeria, the introduction of higher import tariffs for rice has not succeeded in stimulating local production nor in achieving the country's policy goal of self-sufficiency in rice. In large part, this is due to under-invoicing of imports or the diversion of imports by smuggling through the country's porous borders. In particular, high rice tariffs not only increase incentives for under-invoicing at the major port, Lagos, but also increase incentives for smuggling

through Benin and Niger over Nigeria's northern border. Under these conditions, changes in tariff rates have a complex set of effects on production, prices, and trade flows that vary across space and reduce the effectiveness of tariffs as a policy instrument for promoting domestic rice production.

In this paper, we utilize a spatial multi-market model for Nigeria's rice trade that explicitly incorporates incentives for informal trade and volumes of rice import flows through both formal and informal channels. Results show that welfare is maximized when marketing costs for rice flows through Benin and Niger that evade the import tariff are equal to the import parity price of rice that flows through official channels from Lagos to northern Nigeria that incur import tariffs. The optimal welfare-maximizing tariff is calculated to be between 25 and 40 percent, depending on the model parameter values used. Rice import tariff rates in excess of this optimal range lead to increased welfare losses for consumers in the South while dampening the effect of the tariff on prices and consumer welfare in both the Central and North regions.

Maintaining tariff rates at the welfare-maximizing level not only prevents further welfare losses to the rice economy, but, by maximizing tariff revenues, this policy generates resources that in principle could be used to increase public investment in rice productivity. Note, however, that, in the absence of increases in productivity, rice imports would account for 33 to 50 percent of total rice supply in Nigeria at the optimal tariff levels. Even if smuggling could be totally eliminated and higher tariffs were enforced, it would require a tariff rate of about 94 percent or higher in order for Nigeria to achieve self-sufficiency in rice. Such a policy would be politically infeasible given the large negative effects of such a tariff level on poorer consumers and on overall economic welfare. Thus, as long as smuggling cannot be prevented, a policy of avoiding excessively high tariff rates, i.e., greater than about 40 percent, while investing more to increase rice productivity and the competitiveness of local rice production and milling technologies is the most feasible long term option for Nigeria to one day approach rice self-sufficiency.

## APPENDIX: MODEL PARAMETERS AND INITIAL DATA

**Table A.1—Own and cross price elasticities of demand ( $\epsilon_{dij}$ ) used in model, by geopolitical zone**

Zone*	$\epsilon_{d11}$	$\epsilon_{d12}$	$\epsilon_{d21}$	$\epsilon_{d22}$
<b>Rural</b>				
North Central	-0.223	0.360	0.829	-0.446
North East	-0.334	0.540	0.982	-0.529
North West	-0.446	0.720	1.113	-0.600
South East	-0.183	0.296	0.387	-0.208
South South	-0.372	0.602	0.782	-0.421
South West	-0.241	0.389	0.509	-0.274
<i>Weighted Ave*</i>	<i>-0.329</i>	<i>0.531</i>	<i>0.855</i>	<i>-0.460</i>
<i>Estimated*</i>	<i>-0.330</i>			<i>-0.460</i>
<b>Urban</b>				
North Central	-0.088	0.205	0.177	-0.412
North East	-0.132	0.307	0.186	-0.434
North West	-0.176	0.409	0.211	-0.492
South East	-0.101	0.236	0.092	-0.215
South South	-0.176	0.411	0.167	-0.389
South West	-0.114	0.265	0.109	-0.253
<i>Weighted Ave*</i>	<i>-0.131</i>	<i>0.306</i>	<i>0.146</i>	<i>-0.341</i>
<i>Estimated*</i>	<i>-0.129</i>			<i>-0.340</i>
<b>National</b>				
<i>Weighted Ave*</i>	<i>-0.288</i>	<i>0.484</i>	<i>0.708</i>	<i>-0.436</i>
<i>Estimated*</i>	<i>-0.240</i>			<i>-0.470</i>

Notes:  $\epsilon_{dij} = \left[ \frac{dQD_i}{dP_j} \frac{P_j}{QD_i} \right], \forall ij = 1,2$  (where 1 = standard local rice, and 2 = premium rice, local and imported).

\* Weighed by regional share of total demand and comparable with estimated values from Gyimah-Brempong and Kuku (forthcoming).

**Table A.2—Own and cross price elasticities of supply ( $\epsilon_{sij}$ ) used in model, by region**

Region	Standard (rural)		Premium (urban)	
	$\epsilon_{s11}$	$\epsilon_{s12}$	$\epsilon_{s21}$	$\epsilon_{s22}$
Central	0.200	1.040	0.150	0.800
North	0.200	0.910	0.180	0.800
South	0.200	0.290	0.550	0.800

Note:  $\epsilon_{sij} = \left[ \frac{dQS_i}{dP_j} \frac{P_j}{QS_i} \right], \forall ij = 1,2$  (where 1 = standard local rice, and 2 = premium rice, local and imported).

The cross price elasticities were calculated using the own price elasticities and the shares of each type of rice to total rice production, as follows:

$\epsilon_{s12} = \epsilon_{s11} \cdot (s_1/s_2)$ ;  $\epsilon_{s21} = \epsilon_{s22} \cdot (s_2/s_1)$ , where  $s_1$  and  $s_2$  are the shares of standard (c1) and premium (c2) in total rice production, respectively.

Central region corresponds to the North Central geopolitical zone. North region aggregates the North East and North West zones. The South region is made up of the three southern zones.

**Table A.3—Average unit freight costs used in model, by geopolitical zone, Naira/mt/km**

North Central (NC)	North East (NE)	North West (NW)	South East (SE)	South South (SS)	South West (SW)
17.96	12.21	13.18	15.13	18.09	22.47

Source: Johnson (forthcoming).

**Table A.4—Average rural and urban marketing costs used in model, by geopolitical zone, Naira/mt**

Zone	Standard		Premium	
	rural	urban	rural	urban
<b>Rural</b>				
North Central	10.8	14.4	17.4	21.6
North East	14.7	19.5	23.6	29.3
North West	7.9	10.5	12.8	15.8
South East	9.1	12.1	14.6	18.2
South South	10.9	14.5	17.5	21.7
South West	9.4	12.6	15.2	18.9
<b>Urban</b>				
North Central	14.4	10.8	21.6	7.9
North East	19.5	14.7	29.3	10.7
North West	10.5	7.9	15.8	5.8
South East	12.1	9.1	18.2	6.7
South South	14.5	10.9	21.7	8.0
South West	12.6	9.4	18.9	6.9

Source: Calculated by author

Notes: These were purposefully kept low due to lack of sufficient data. They are calculated based on distances between state capitals (from Johnson, forthcoming) to serve as weights and unit costs of 0.75 Naira/kg (rural to rural marketing), 0.55 (urban to urban), and 1.00 Naira/kg (rural to urban), and 1.50 Naira/kg (urban to rural).

**Table A.5—Baseline local production of standard and premium rice varieties in Nigeria, by state, 2009, thousands mt**

State and zone	Standard (local)		Premium (local)		State and zone	Standard (local)		Premium (local)	
	Rural	Urban	Rural	Urban		Rural	Urban	Rural	Urban
<b>North Central</b>					<b>South East</b>				
Benue	217.2	0.0	0.0	115.2	Abia	2.7	0.0	0.0	0.0
FCT-Abuja	4.4	0.0	0.0	0.0	Anambra	1.9	0.0	0.0	0.0
Kogi	75.3	0.0	0.0	0.0	Ebonyi	183.6	0.0	0.0	115.2
Kwara	49.7	0.0	0.0	0.0	Enugu	55.5	0.0	0.0	57.6
Nasarawa	71.0	0.0	0.0	57.6	Imo	0.6	0.0	0.0	0.0
Niger	401.8	0.0	0.0	0.0	<b>South South</b>				
Plateau	78.7	0.0	0.0	0.0	Akwa-Ibom	1.4	0.0	0.0	0.0
<b>North East</b>					Bayelsa	0.3	0.0	0.0	0.0
Adamawa	156.1	0.0	0.0	0.0	Cross River	1.8	0.0	0.0	0.0
Bauchi	33.0	0.0	0.0	0.0	Delta	1.3	0.0	0.0	0.0
Borno	185.3	0.0	0.0	0.0	Edo	11.7	0.0	0.0	0.0
Gombe	66.6	0.0	0.0	0.0	Rivers	0.0	0.0	0.0	0.0
Taraba	176.9	0.0	0.0	0.0	<b>South West</b>				
Yobe	53.5	0.0	0.0	0.0	Ekiti	36.0	0.0	0.0	0.0
<b>North West</b>					Lagos	4.6	0.0	0.0	0.0
Jigawa	41.6	0.0	0.0	0.0	Ogun	6.0	0.0	0.0	57.6
Kaduna	454.1	0.0	0.0	57.6	Ondo	26.3	0.0	0.0	0.0
Kano	262.8	0.0	0.0	230.4	Osun	1.7	0.0	0.0	0.0
Katsina	21.2	0.0	0.0	0.0	Oyo	0.1	0.0	0.0	0.0
Kebbi	52.9	0.0	0.0	57.6					
Sokoto	45.8	0.0	0.0	0.0					
Zamfara	24.8	0.0	0.0	0.0					

Source: NAERLS, 2009

Notes: Production of standard (local) rice occurs in rural areas while production of premium (industrial milling) occurs in urban centers only.

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